

ATTACHMENT III

ABSTRACT

This invention teaches two new families of Si-based $\text{Ge}/\text{Sn}_x\text{Ge}_{1-x}$ heterodiode and multiple quantum well (MQW) photonic devices: (1) *band-to-band* photodetectors, lasers, emitters, amplifiers and modulators for the 1.5 to 12 μm wavelength range; (2) *intersubband* photodetectors, lasers, emitters and modulators for 12 to 100 μm operation. The bipolar band-to-band devices have applications within the 1.5-2.2, 3-5 and 8-to-12 μm bands. The unipolar intersubband group has longwave infrared and terahertz applications. All strained-layer devices are grown a relaxed $\text{Sn}_y\text{Si}_z\text{Ge}_{1-y-z}$ buffer layer-- a virtual substrate (VS) grown directly upon a silicon wafer by unique LT UHV-CVD. The VS provides a low-defect atomic template for subsequent heteroepitaxy and is an essential enabling technique for engineering tensile and compressive strain within the $\text{Ge}/\text{Sn}_x\text{Ge}_{1-x}$ MQW by selecting the VS lattice parameter to be approx midway between the layer lattices.